Western Region Technical Attachment
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# QUESTIONS AND ANSWERS ABOUT EL NINO

*What is El Nino?*

El Nino is a term generally referring to episodes of warmer than normal sea surface temperatures in the central or eastern (near South America) tropical Pacific Ocean. This warmer water can produce large changes in the atmospheric circulation in distant parts of the globe. The name "El Nino" ("the child" in Spanish) comes from the fact that the effect usually appears along the western coast of South America in the late fall and early winter, around Christmas.

*What Are the Atmospheric Effects of El Nino?*

The most significant atmospheric effects are found in the tropics, but effects in other parts of the globe are sometimes observed. In the tropics, the warm waters in the central or eastern Pacific warm the lowest layers of the atmosphere, generating instability and deep convection. The upward motion in this convection is usually compensated with downward motion in other areas in the tropics. In a typical El Nino, the downward motion is usually concentrated over Indonesia, northern Australia, southern Africa, and northern South America. This downward motion reduces the normal convection in these areas and creates severe drought.

In areas outside the tropics, the atmospheric response is weaker, more variable from one El Nino episode to another, but still discernable in some areas. If El Nino conditions produce convection in the central Pacific during the Northern Hemisphere winter, the subtropical jet stream across the eastern Pacific and into northern Mexico is enhanced. This unusually strong jet can affect the main pattern of westerlies across the eastern Pacific, western North America, and the southern U.S. The most typical response is for a "split" to develop in the westerlies approaching the west coast of North America. The northern branch of this split typically steers storms approaching the Pacific Northwest, northward into the Yukon, and then southward into the eastern U.S. The southern branch typically steers storms heading for California southward, merging with the enhanced subtropical jet stream and driving storms across northern Mexico and into the southeastern U.S. This split in the flow usually leads to warmer than normal temperatures in the Pacific Northwest and British Columbia, and wetter than normal conditions in the Southeast. It is also not uncommon for the warmth in the Pacific Northwest to be accompanied by drought and for the storms moving through northern Mexico to brush the extreme southwestern U.S. and produce unusually heavy rainfall.

*How Consistent Are the Effects Over the U.S.?*

*Not very.* As mentioned above, the most consistent impact is felt in tropical areas. The exact position of the warm water in the central or eastern Pacific (either slightly north or

south or slightly west or east) can have a major impact on the atmospheric response over the U.S. The time of year when the warmest waters are observed can also have a significant impact. When statistically correlating warm waters in the Pacific with weather in North America, the most consistent response is abnormally warm temperatures in British Columbia, and abnormally wet conditions in the Gulf Coast region. Other effects (such as drought in the Pacific Northwest and abnormally wet conditions in southern California and Arizona) are less consistent.

### *What Are the Effects in the U.S. During the Summer?*

*Very little.* The major effects (warm in British Columbia, wet in the Gulf Coast region) are observed during the winter and spring months following the start of the warm El Nino waters. The strongest and most consistent atmospheric response outside of the tropics is usually felt in the "winter hemisphere". Thus, during the summer in the U.S., the most significant response shifts to the Southern Hemisphere.

### *What Causes El Nino to Start?*

A complex interaction of ocean currents, atmospheric winds, and the elevation of sea level initiates the El Nino warming. During 'normal' years, there is a large low-pressure area of warm, moist air over the western tropical Pacific and Indonesia. At the same time, there is a high pressure area of relatively cooler, drier air over the eastern Pacific and the west coast of South America. These consistent pressure differences keep strong easterly trade winds blowing across the tropical Pacific. The easterly winds are steady enough to sweep more of the warm surface waters of the ocean to the western part of the Pacific than the eastern part. In fact, the sea level surface averages about one half meter higher near Indonesia than along the South American coast.

During an El Nino, the surface pressure difference between South America and Indonesia relaxes, and sometimes even reverses. This causes the trade winds to weaken, and occasionally they even blow westward. With no steady winds to support the higher sea levels in the western Pacific, the water tries to equalize sea level by flowing in the other direction. This adjustment process usually manifests itself as a wave of warmer water that rapidly moves eastward across the Pacific. When this wave hits the South American continent, the sea level rapidly rises, and sea surface temperatures can warm as much as six degrees Celsius in a few days. This wave of warmer water can also be deflected north and south along the Central and South American coasts. As the sea level continues to adjust, the normally thin layer of warm surface water in the eastern Pacific becomes deeper and warmer (the "El Nino" warming) and begins to influence the overlying atmosphere.

### *How Fast Does El Nino Develop?*

Oceanic currents and temperatures evolve much more slowly than the winds and temperatures in the atmosphere. Some features of the El Nino, such as the warm water waves that hit South America, move rapidly and can change local ocean conditions within a few days. However, it usually takes several months for the larger area effects to fully evolve.

*Can El Nino Be Predicted?*

*Yes.* The slow evolution of oceanic currents and temperatures means that it may be possible to predict El Ninos as far in advance as a year or more. Models did a fair job of predicting the 1991-92 El Nino a year in advance, although the strength of the warming was underforecast. Keep in mind that these long-range predictions of the oceanic warming are not the same as long-range predictions of the atmospheric response. Fairly accurate predictions of the ocean warming are possible (although they still have problems and inaccuracies), accurate long-range predictions of the tropical response to such a warming are less reliable, and accurate long-range predictions of the global response to any particular warming episode (such as the response over the U.S) are probably impossible.

*How Often Does El Nino Occur?*

The El Nino phenomena is usually described as 'semi-cyclical' or 'episodic'. A warming event usually occurs every 2-10 years. The last three El Nino warmings have been in 1982-83, 1986-87, and 1991-92.

*Is the Ocean Affected Outside of the Tropics?*

*Yes.* As mentioned above, waves of warm water hitting the South American coast can be deflected north and south along the coasts of Central and South America. Also, the large changes in the distribution of heat in the ocean can cause the disruption of many ocean currents far from the tropics. Also, when the atmospheric response to an El Nino is strong and steady, the atmosphere can force changes to local ocean currents. For example, during the winter of 1991-92, abnormally strong, steady westerly winds across the north central Pacific swept waters higher along the coast of Southern California. These waters reduced the normal upwelling along the California coast, and created unusually warm conditions, as well as record high sea level elevations. Such local effects can have a significant impact on local weather, but the large-scale atmospheric pattern is controlled more by the large changes in heat and moisture that initiate in the tropics.

*Does El Nino Have Other Serious Impacts?*

*Yes.* Probably the most significant impact is to marine life along the western coasts of North and South America. Fish that normally feed in the cooler, nutrient-rich ocean waters along the coasts are displaced by the warmer, nutrient-poor waters. Tropical fish are often found in unusually large numbers in areas far from the tropics. For example, during 1991-92, tropical pelagic red crab were found in the waters off Northern California, far north of their normal range. Barracuda and bonito, usually found only in Southern California waters, were caught in Northern California and Oregon. The unusual conditions affect many species, including commercial fish stocks that normally thrive in cooler waters and that suffer during warm events. Sea birds that feed on the normal population of fish in coastal waters often migrate great distances north and south to find their typical prey. Other marine life such as kelp and plankton are also affected.